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Internal Research Report / Rapport Interne de Recherche n° RR/08-03

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Abstract

This paper aims at presenting an Anticipative Effects-Based Approach (AEBA) to evaluate the potential effects of a collaborative crisis management process response on the different elements concerned by the crisis evolution. This approach provides several concepts, model and reasoning mechanisms presented and illustrated in this paper. AEBA is currently developed within the French ISYCRI[1] Project. It focuses on crisis occurring suddenly and unpredictably. Long time crisis such as famine, pandemic, enduring civilian wars, etc. are not taken into account.

1. Introduction

In crisis situation, numerous actors from different organizations have to work altogether. Their ability to control and to reduce crisis depends of the coordination and the synchronization of their actions expressed through a collaborative process. Although the main desired effects of this process are to solve crisis, some others effects (unpredicted, undesirable…) can be induced and then make matters worse. As a consequence, it is necessary to analyze from an anticipative manner the different effects that can be produced in order to help managers in charge of the collaborative process to adapt it prior to its execution. This paper aims at presenting and illustrating the concepts and the methodology associated to an Anticipative Effect-Based Approach (AEBA) allowing to evaluate potential effects (direct and indirect) of actions.

[1] ISyCri stands for Interoperability of Systems in situation of Crisis and is supported by the French Research National Agency (ANR).

AEBA is inspired from Effects-Based Approaches, better known as Effects-Based Operations (EBO) in the military field, and then does not embody a new concept [1]. However - whilst EBO are mainly developed for military purpose - the fundamental idea is appealing and it is interesting to behold how these concepts could be developed and applied to support the collaborative process and to guide its management.

The objectives of this research work are presented in section 2. The concepts of Effects-Based Operations are discussed in section 3. Section 4 shows the relationships which consistently relate these concepts and those developed in crisis area are outlined. To illustrate the use of the proposed effects-based approach, a simplified case study is shown in section 5 before concluding the paper in section 6.

2. Objective of the AEBA

Anticipative Effects-Based Approach focuses on the collaborative process that is commonly set up to react to the crisis, which involves the different participants. To achieve a full reasoning in crisis situation, the AEBA must consider two kinds of configuration of the collaborative process:

1. The collaborative process was originally set up according to existing plans. In this case, the produced effects of the different actions involved in the process must be analyzed and evaluated;
2. The collaborative process that was originally set up is no longer able to react to the crisis evolution. In this case, it is necessary to propose a new possible sequence of actions that can be executed in order to produce the expected effects and to face the crisis.

To carry out the two previous points, the AEBA has to provides a set of concepts and rules that allows to model and to reason about situations, characteristics, or

possible configurations of each element confronted to the crisis. The goal is to analyze the relevance of the potential effects (direct or indirect) and to help actors to make evolve the collaborative processes of crisis response to produce fine effects. Expected result of the proposed research work is to formalize a crisis model and a referential of rules that allows first, to design and second, to analyze this model in order to guide the actors during crisis management..

3. State of the Art

According to [2] [3] [4], Effects-Based Operations are concerned by the execution of actions in order to produce the required effects that allow attaining a desired final outcome. EBO is thus related to the concepts of actions, effects and outcomes. Actions are operations that transform an object from one state into another state. An action is supported by means and resources that contribute to its execution, in order to produce the required effect. Effects are the results of actions that display the modification of an object state.

The literature classifies effects as direct (1st order) indirect (2nd/nth order), predicted or unpredicted, desirable or undesirable, decisive, enabling… Last, final outcomes represent the desired situation that will have to be achieved. These three concepts represent the structure of an EBO as shown in figure 1.

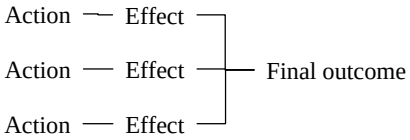

Figure 1. Simplified structure of an EBO (adapted from [5]).

The implementation of an EBO is defined by a cycle composed of phases named knowledge, planning, execution and assessment. The *knowledge phase* allows to define clearly the situation including final outcomes desired, effects required, means, possible actions that can be carried out. The *planning phase* consists to organize actions. The *execution phase* performs the actions and induces some effects. Finally, *assessment phase* allows to evaluate the real effects and to adjust the planned actions.

However, literature on EBO still remains focused on theory with a lack of practical application [6] and without formalized methodologies allowing to anticipate the effects. So, taking into account the objectives of AEBA defined in section 2, the main interesting phase remains the knowledge phase during which it is necessary:

- To gather a maximum of possible knowledge that can be used in order to characterize all the elements confronted to the crisis and to build a model of this crisis highlighting potential effects of the proposed collaborative process on these elements.
- To test a set of analysis rules and therefore to anticipate all potential effects. Indeed, the flawless cognition of the nature of an effect caused by an action (or a set of actions) has to allow a better management of the process in order to response suitably to the crisis.

4. Characterization

This section introduces the concepts and definitions related to a crisis characterization used in the AEBA.

4.1 Crisis characterization

Several elements inspired by [7] are required in order to characterize a crisis

- The Operative Zone (**OZ**) defines the location where the crisis takes place (in a broad sense, for example, the place where a family of a victim lives is also included into the operative zone), as well as environmental conditions such as geographic and climatic.
- The Operative Duration (**OD**) is the time interval between the date at which first actions are executed and the date at which the crisis is over.

It is to note that, all elements outside of the OZ or inexistent during OD are not considered. All the other elements can be affected by the crisis, involved in its evolution, or participate to its resolution. Several categories of elements exist:

- The Population (**P**) is the set of physical people who are directly affected by the crisis.
- The Civil Society (CS) is composed of peoples and civil associations that can be confronted indirectly to the crisis, such as victims' families, media, etc.
- The Natural Environment (**NE**) is constituted by the environment, excluding human constructions. Thus, the natural environment can be seen as the set of elements such as woods, air lanes, navigable lanes, *etc.*
- The Goods (**G**) are habitations, roads, vehicles… and all other infrastructures that can be affected by the crisis.
- The Human Means (**HM**) gather on-site and off-site participants that are involved in the collaborative process. They provide their resources, services, *etc.*
- The Material Means (**MM**) is the set of available resources (energy, material, machines, etc.) for HM, CS and P.
- A Gravity Factor (**GF**) is any element that can impact the crisis, either in a positive way (improvement of the situation) or in a negative way

(worsening of the situation). A gravity factor affects one or several characteristics of the elements of the OZ during OD for example in terms of performances (*e.g.* operative duration is longer than predicted).

- A Complexity Factor (**CF**) is any element that modifies the type of the crisis. Usually, a complexity factor requires redefining the collaborative process response because of the evolution of the crisis. Indeed, OZ and OD must be modified and the elements confronted to the crisis may change. Last, a gravity factor can become a complexity factor. For example, the rain can be considered as a positive gravity factor on a fire but can turn into a complexity factor if it causes a flood.

In crisis context, all these elements must be clearly identified and characterized themselves as follows.

4.2 Element characterization

Any element must be defined and characterized, using the following concepts.

The first concept is related to the **TSS** (Time, Shape and Space) referential [3]. It allows defining and formalizing physical attributes which characterizes any from a quantitative or qualitative manner element evolving in the time (limited by OD), in the space (limited by OZ) or taking into account its shape. Any element may be "a part of" or "interacts" with another element. In this case, the evolution of each element affects and modifies the referential of the surrounding elements. Thus, defining which elements evolves in a given referential allows to know the impact of these elements on their environment.

The selected attributes are:

- **Time:** *date* and *duration*;
- **Space**: *localization* and *dynamic* (in term of evolution of the object).
- **Shape:** *influence* (of the object on its environment in terms of skills, authority…), *dimension* (volume, length…), *vulnerability* (improvement or degradation of the object), *quantity*, *complexity* (organic, structural…) and *cost* (related to or inferred by the element or its utilization);

Elements involving people must be characterized by interpreting some particular TSS attributes related to human behavior and psychological profile of any people involved in the crisis. In the current state of the work, some shape attributes have been defined thanks to [3bis]:

- **Believe:** this attribute represents the knowledge level and the psychological state of the people when facing to crisis situation. Believe is described by the attributes named competence level, experience level and confidence level of the people.
- **Desire**: this attribute represents the requirements of the people in terms of health, safety and security.
- **Intention**: this attribute represents the expected behavior of the people facing a new situation in term of autonomy of the people and relevance of its decision.

The second concept is called **modality** [4]. It allows characterizing elements from type of action, human or material mean. These elements [8] are considered as complex elements which can be defined by a mission (what it has to do?), a finality (why it must do it?) and (a set of) objective(s) (how is it possible to know if the mission is achieved?). Modalities summarized below, allows to define more precisely this kind of complex system [9]. They are explained such as requirements as follows:

- The modality 'to know' (TK) represents what is required by the element in terms of knowledge and skills to achieve its mission;
- The modality 'to be able to' (TBA) represents the set of resources that are required by the element. A resource is able to provide skills, capabilities, data, information, knowledge, matter, and energy that are needed to achieve mission;
- The modality 'to want' (TW) represents the set of inputs such as data, information, knowledge, rules, events and order that are required by the element to control its behavior and to achieve its mission;
- The modality 'to have' (TH) represents the set of inputs required by the element to achieve finality.
- The modality 'to have to' (THT) represents the sets of outputs that must be achieved by the element representing its mission.

Figure 1 gives a representation of the modalities for a given object.

Last, the concept of **interaction** [5] [6] allows formalizing how, in which condition, and with which effects an element can dynamically interact with another:

- The interaction "know-how" (KH) represents the flow of knowledge and skills;
- The interaction "want-do" (WD) represents the flow of input that triggers the object;
- The interaction "can-do" (CD) represents the flow of inputs that are considered as resources;
- The interaction "must-do" (MD) represents the flow of final outputs.

In summary, each element is characterized by defining its attributes on a given TSS referential, its modalities with its environment and the interactions that are required from this environment. When done, the second step of the knowledge phase consists to design the model of the crisis.

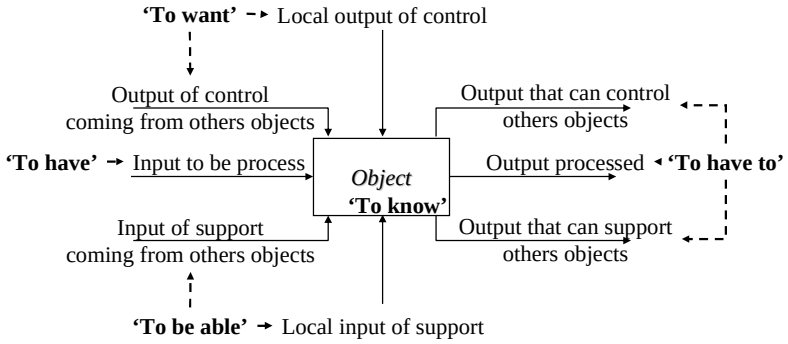

Figure 1. Representation of the modalities for a given object

4.3 Effects model design

The crisis model formalizes the effects (direct and indirect) induced by the proposed collaborative process. It uses an effect based model inspired by the su-field model [7] and schematized in fFigure 2.

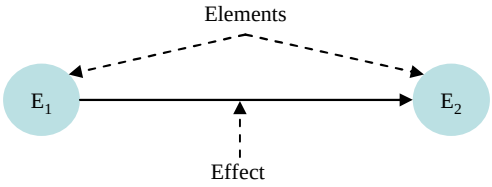

Figure 2. Graphical notation to represent the model of effects

There is an effect if and only if an element (present in the OZ during OD), considered as the source of the effect (E_1) could modify (*i.e.* it could influence the modification) of one or several TSS attributes and/or one or several modalities of a second element (E_2).

Any direct effect results directly from one or several interaction such as defined above. An effect may be considered as an indirect effect if it results from a consequence of a direct effect itself.

Last an effect is typed as:

- Nefast: the effect induces a high modification which affects one or several crisis elements and that must be reduced absolutely.
- Good: the effect must be carried on in order to solve the crisis. This effect is then required absolutely.
- Absent: the effect of this interaction is expected but is not a real effect of the proposed collaborative process at this moment.
- Excessive: the effect must be reduced but kept.
- Insufficient: the effect is required but it must be enhanced in order to be considered as relevant.

Figure 3 shows the graphical notations which are commonly used for effect types representation.

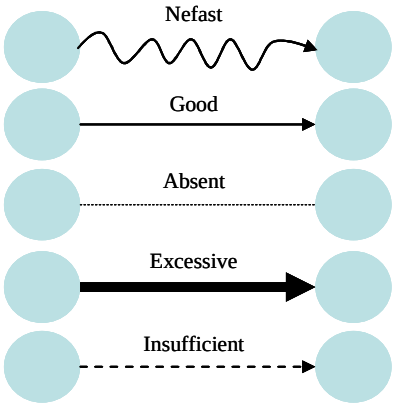

Figure 3. Graphical notations to represent the characteristics of the effects

Typing an effect takes into account:

- The nature of the crisis.
- The evolution swiftness of the crisis.
- The type of respectively the source element and the destination element.
- The nature of the modified attributes or modalities of the destination element.
- The type of effect (direct or indirect).

The current work is now defining rules allowing to find automatically and to type each effect and then to design the crisis model. In general way, a rule can be expressed by an idiomatic expression such as "*if the resource (element 1) cannot (interaction can do) provide the totality of the resource required by the activity (element 2) extending its time duration (modification of the time attribute) then the effect produce by the resource is insufficient and direct" and* allows to characterize the effect produce by a resource in relation to an activity

This model is then used in order to reason. This phase is based on the performing on this model of some analysis rules allowing evaluating potential effects of the proposed collaborative process on the crisis

4.4 Effects model analysis rules

Analysis rules allow to reason about the effects of an element on another. The main purpose is to provide lines of solutions to help managers to adapt the collaborative process. Here so, it is needed to define rules to perform analysis.

As an example, the rule, *"if the effect is insufficient and modifies the Time duration attribute of the element then other resource can be required or activity can be triggered sooner…"* is an analysis rule giving lines of solutions to the managers in order to adapt the collaborative process and to counter the insufficient effect.

At the end of this research work, a set of rules allowing to build the model of effects and on the other hand, allowing to analyze these effects, have to be done in order to perform fully the AEBA

5. Illustration

This section proposes a concrete crisis scenario with the application of the concepts that define the AEBA.

5.1 Presentation of the crisis scenario

Let us consider the following crisis scenario. *At 6 pm an accident involving cars, motor coach (transporting foreign tourists) and a freight truck (hazardous substance) has occurred in a French tunnel on freeway in a mountainous area. A first assessment states numerous deaths (approximately 65), injuries (approximately 40 people) and other victims with no physical injury (approximately 20). A traffic jam has formed at the entrance of the tunnel. The night is falling and a rain is expected.*

Using the previous definitions and concepts, it is possible to apply the anticipating effects-based approach.

5.2 Applying AEBA

For practical reason and to show the interest of the AEBA, the following application is intentionally reduced and takes only in consideration the activity "to evacuate victims". This activity is characterized by the following TSS attributes:

- Time: beginning of evacuation at 7 pm (1 hours predicted)
- Shape: evacuation of the deaths, injuries and other victims with no physical injury.
- Space: tunnel on the freeway

Its modalities are defined as follow:

- To know: numbering of victims, working in hostile atmosphere
- To be able to: 50 persons to evacuate
- To want: order to evacuate
- To have: victims
- To have to: victims evacuated

Let us consider a resource, such as firefighters, having the following TSS attributes:

- Time: on-site at 7 pm
- Shape: 25 firefighters
- Space: fire station

The first step is related to the construction of the model of effects using rules. As far as the interaction "can do" is concerned, the firefighter will can not provide the totality of the resource required by the activity. This situation finds expression by the rule: *"if the resource (element 1) cannot (interaction can do) provide the totality of the resource required by the activity (element 2) then the effect produce by the resource is insufficient and direct"*. For this rules the effects is clearly insuficient since the expected effects of the resource is to provide all the human means required by the activity. The element source of the interaction (resource) could modify TSS attribute time duration of destination element (activity).

Furthermore, this effect has an influence on the activity, especialy on the interaction "must do" defined as "victims evacuated in 1 hour" and which represent the expected effect of the activity. As far as the model of effects is concerned this influence is traduce by the rule *"if the activity does not fully that it has to do and impairs the processed element, then the effect produce by the activity is insufficient and indirect"*. The element of the interaction (activity) modifies the TSS attributes shape of the second element (victims).

Thus, it is possible to draw the model of effects such as illustrated in the Figure 4.

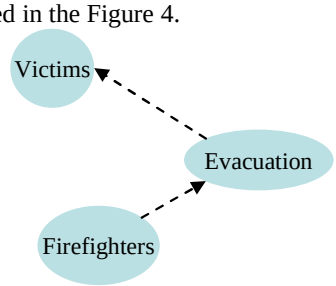

Figure 4. Graphical model of the effects

Then it is necessary to analyse these effects using analyses rules. Thus, the defined rule *"if the effect is insufficient and modifies the Time duration attribute of the element then other resource can be required or activity can be triggered sooner…"* can serve as lines solutions.

Starting from this analyse, the managers have to modify the collaborative process in order to obtain the expected effects. In this example if the managers decide to require others resources and these resources are available, then the insufficient effect produces by resource will be counter and will be good. Furthermore, the indirect effect will be counter too.

6. Conclusion

This paper has presented the first concepts of an Anticipative Effects-Based Approach (AEBA) for helping the management of a collaborative process of crisis response. These concepts allow characterizing elements and crisis. The effect model may be then designed and analysis may be performed. They constitute the here proposed Anticipative Effects Based Approach summarized Figure 5.

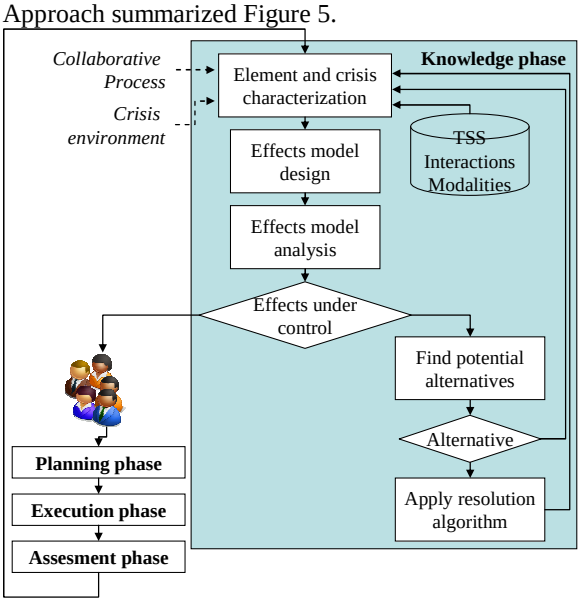

Figure 5. Process of the Anticipative Effects Based Approach

A simplified example has presented the principles of the AEBA approach. Let us notice this research project is under development, and whilst concepts are clearly identified, a complete set of rules has to be defined and formalized. Thus, future work is concerned by the development of these rules.

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